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ABSTRACT

This paper presents a procedure by which institutional researchers can determine whether gender-salary discrimination exists at an institution of higher education. The procedure utilizes a statistical quality control tool, which is referred to as setting the process aim. This procedure is based on the premise that salaries are determined by a salary system. Since the values produced by any system will exhibit some variation, the value used to measure the difference between the salaries of the female and male faculty, which is generated by multiple regression analysis of the salary data, will vary from year to year. In order for institutional researchers to determine if the salary system has led to gender-salary discrimination, the noise of the system must be separated from a gender salary discrimination signal. Applying the process aim setting technique to the values obtained from the multiple regression analyses of multi-year data will enable researchers to separate a gender salary discrimination signal from the normal variation in those values. A demonstration of this technique, using hypothetical salary data, is included. (Contains 17 references.) (Author/MDM)

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Setting the Process Aim in A Gender Salary Discrimination Study: A Statistical Process Control Approach

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Paper presented at the Annual Conference of the Eastern Educational Research Association Hilton Head, South Carolina March 1-4, 1995

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Abstract

This paper presents a procedure by which an institutional researcher can determine whether gender-salary discrimination exists at an institution of higher education. The procedure utilizes a statistical quality control tool, which is referred to as setting the process aim. This procedure is based on the premise that salaries are determined by a salary system. Since the values produced by any system will exhibit some variation, the value used to measure the difference between the salaries of the female and male faculty, which is generated by multiple regression analysis of the salary data, will vary from year to year. In order for institutional researchers to determine if the salary system has led to gender-salary discrimination, the noise of the system must be separated from a gender salary discrimination signal. Current methods used by institutional researchers do not accomplish this task. Applying the process aim setting technique to the values obtained from the multiple regression analyses of multi-year salary data will enable institutional researchers to separate a gender salary discrimination signal from the normal variation in those values.

Setting the Process Aim in A Gender Salary Discrimination Study: A Statistical Process Control Approach

Numerous articles and reports have been generated over the past 20 years that discuss methods used to determine whether gender-salary discrimination exists at an institution of higher education. Various methodological approaches have been suggested. For example, Heiny, Houston, and Cooney, (1984) utilized canonical analysis and discriminant analysis to investigate gender-salary discrimination. Bereman and Scott (1991) used compa-ratios to detect gender bias in faculty salaries.

Gray (1985), Smart (1991), and Tesfagiorgis (1991) noted, however, that the methodological procedure of choice involves the use of multiple linear regression models. Tesfagiorgis stated that:

> The multiple regression analysis, which was introduced to the legal community in the 1970s, is emerging as the most common statistical method used to prove the existence or the absence of discrimination in hiring and promotion practices. Its increasing success, as a statical [sic] tool in Title VII cases, lies in its ability to show the effects of several legitimate factors on an employment decision (pp. 1-2).

Moore (1993) discusses four primary statistical questions that the researcher must address when conducting a salary equity study that utilizes multiple regression models:

1. Who should be included in the model(s)?
2. What variables should be included in the model(s)?
3. What procedures should be followed to construct the statistical model(s)?
4. What statistical values should be used to interpret the results?

Moore states: "The direction and magnitude of the final results are contingent on the way these statistical decisions are made. Therefore, careful consideration of these issues is essential for conducting a fair and defensible salary equity study" (p. 108).

It is the last of the four questions posed by Moore (1993) that is the focus of this paper. Specifically, the issue addressed in this paper is the technique used by an institutional researcher to decide whether the multiple regression values generated in a salary equity study allow the institutional researcher to conclude that gender-salary discrimination is present and, thus, indicate that corrective action is warranted.

Moore (1993) and Allard (1984) have raised serious questions concerning the techniques currently used, or the lack thereof, to conclude that gender-salary discrimination exists. To deal with these concerns, I am proposing that a statistical quality control technique referred to as setting the process aim be used to determine whether the regression results generated by a salary equity study do, in fact, indicate the presence of gender-salary discrimination.

The remaining sections of this paper discuss: (a) the two major methods of investigating gender-salary discrimination that use multiple linear regression models, (b) the need for a new technique that can identify a gender salary discrimination

signal, (c) the two features required of any technique used to identify a gender salary discrimination signal, (d) the application of the process aim setting technique to hypothetical examples, and (e) three issues related to the use of the process aim setting technique when it is applied to salary data.

Use of Multiple Regression Models

Moore (1993) and Gray (1990) stated that the methodology that utilizes multiple linear regression models to investigate salary equity can be divided into two major types. One methodological approach requires that a multiple linear regression model be designed to analyze the male faculty members' salaries (Scott, 1977; Gray & Scott, 1980; and Gray, 1990). This methodology, which will be referred to as the male-model approach, regresses the salaries of the male faculty members onto a set of predictor variables. These coefficients are used in conjunction with the data recorded for each female faculty member to calculate her predicted salary. Gray (1990) states that "this method [predicted salary] measures what a woman would be paid were she paid as the average of men with her qualifications would be paid" (p. 3).

In a salary equity study that utilizes the male-model approach, the average of the differences between the actual salaries and predicted salaries for the female faculty members, which is referred to as the average residual value, is calculated. As noted by Gray (1990) "the average residual [value] measures the difference between the salaries of men and women with the same qualifications insofar as the variables of the model are concerned" (p. 3). Thus, institutional researchers use this average

residual value to measure the diffrence between the salaries of female and male faculty.

The second methodological approach, which will be referred to as the one-model approach, incorporates both male and female faculty members in one regression model. The effect of gender is captured by the inclusion of a predictor variable that consists of 0 and 1 values depending on the gender of the faculty member. It should be noted that it is not uncommon for the faculty salaries to be transformed to a natural log value (Becker & Goodman, 1991 and Gray, 1990). This transformation is based on the semilogarithmic earnings function introduced by Mincer (1974). As noted by Becker and Goodman, when the faculty salaries have been transformed to natural log values, and the male and female faculty members are assigned the values of 1 and 0, respectively, the following equation can be used to calculate the percent by which male salaries either exceed or fall short of the female salaries:

$$\% \text{ difference} = 100 (e^{b} - 1) \qquad \text{[Equation 1]}$$

where:

1. e is equal to 2.71828.
2. b represents the regression coefficient value for the gender variable.

If the salaries of the female and male faculty do not differ, adjusting for the other predictor variables, the institutional researcher would expect the coefficient value for the gender variable to equal zero. If the female salaries are less than the male

salaries, adjusting for the other predictor variables, however, the coefficient for the gender variable would exceed zero. The gender coefficient or the percentage difference between male and female salaries, adjusting for the other predictor variables in the model, is used by institutional researchers as a measurement of the amount of gender-salary discrimination in the salary data.

Evaluating the Gender Salary Discrimination Values

Regardless of which regression approach is used to estimate the difference between the salaries of the female and male faculty, the researcher must determine if these values provide sufficient evidence to indicate that salary-gender discrimination does, in fact, exist. If one considers the male and female faculty salaries to be generated by a salary system, one would expect a certain degree of year-to-year variation to exist in the values that measure the difference between female and male salaries. Specifically, one should expect the average residual value and the percentage difference between male and female salaries, as estimated through the regression procedures previously discussed, to vary from year to year. In fact, Lassiter (1983) documented year-to-year variation in the regression coefficient for the gender variable in a salary equity study that utilized the one-model approach.

Thus, an institutional researcher is faced with the task of implementing an evaluation procedure that will identify a gender-salary discrimination signal in salary data generated by a discriminatory salary system. This evaluation procedure must also not signal the existence of salary-gender discrimination when the salary data are

generated by a nondiscriminatory salary system. Specifically, when the male-model approach or the one-model approach is used, the evaluation technique must be able to identify whether the female average residual value or the regression coefficient for the gender variable represents a gender salary discrimination signal or simply the variation of those values around the value of zero, which would indicate no gender discrimination.

Concerns with the Current Evaluation Techniques

In the male-model approach, as previously discussed, the average residual is used to measure the difference between the salaries of the female and male faculty. Allard (1984) noted that "the greatest disadvantage with the male-model strategy is the lack of a formal test to indicate whether the salary differences are statistically significant" (p. 6). Currently, institutional researchers appear to make the assumption that any negative average residual value is evidence of gender-salary discrimination regardless of the average residual values for the previous years, which are often not even estimated. No attempt is made to determine if the negative average residual value is simply a reflection of the variation of the average residual values around zero, which would indicate the lack of gender-salary discrimination in the salary system. In such a case, no adjustment should be made in the faculty members' salaries. As stated by Wheeler (1991): "It will always be folly to make adjustments [in the process] in the absence of a signal indicating that an adjustment is needed" (p. 44).

When the one-model approach is used to analyze salary data, the concern is not that institutional researchers fail to determine whether the gender coefficient indicates the presence of the gender salary discrimination signal. It is the technique used by institutional researchers that causes concern. Moore (1993) noted that "in salary equity studies, the statistical significance of a sex coefficient is often used as an indicator of discrimination" (p. 119).

To determine whether there is evidence that the salary system is discriminatory, the institutional researcher must determine if the year-to-year differences between the female and male faculty members' salaries are stable at a level other than zero. The problem with statistically testing the gender coefficient for a given year salary data is that such a test does not indicate the stability of the coefficient over time. Thus, a statistical test of the gender coefficient is not the correct technique for determining if the coefficient value signifies that gender-salary discrimination exists in the salary system.

Feature Required of the Evaluation Technique

The absence of a procedure to evaluate the average residual values produced by the male-model approach and the inappropriate use of a statistical test of the gender coefficient produced by the one-model approach suggests that a new technique is needed. Since salaries are generated by a salary system, which causes the regression estimates of the gender-salary differences to vary from year to year, any new technique used by institutional researchers must incorporate two features.

First, the salaries generated by the salary system must be evaluated more than once. Second, the year-to-year variation in the values used to measure the difference between the female and male salaries, such as the average residual values in the male-model approach or the regression coefficient values for the gender variable in the one-model approach, must be measured and incorporated into the evaluation technique.

The desirability of using a technique that requires more than one observation of the process is suggested by Stevens (1971), and Moore (1993). Stevens stated that "in the long run scientists tend to believe only those results that they can reproduce. There appears to be no better option than to await the outcome of replications" (p. 440). Moore (1993) expressed a similar view with respect to the importance of replication as it relates to salary equity studies when she wrote:

> The primary reason that the courts look at significance test is to eliminate chance as an explanation for the results. There is a more direct way to address this concern. Salary equity studies can be replicated by repeating the study in each of several past years. The cumulative results will be indicative of the 'pattern and practice' of the institution and should satisfy the court's concern in this regard (p. 120).

The second requirement of any technique used to evaluate a system, such as a salary system, is that the degree of variation in the values being monitored must be measured and incorporated in the evaluation technique (Wheeler, 1994 & 1991). Wheeler (1991) stated that:

> Any failure to first determine the process dispersion will inevitably result in incorrect and inappropriate adjustments of the process aim. One simply cannot make an intelligent decision as to whether the process average is close to the target value without some measure of process dispersion (p. 43).

Though the values used to measure the difference between the salaries of the female and male faculty will vary from year to year, they should center around zero in a nondiscriminatory salary system. The institutional researcher can determine if these values do not center around zero only when their year-to-year variation is considered.

Setting the Process Aim

Wheeler (1991) presents a statistical control technique that is known as setting the process aim. I am proposing that this technique be adopted for use in a salary equity study. I believe that it is the appropriate method of determining whether gender-salary discrimination exists because it incorporates the two features that were previously discussed. That is, when the process aim setting technique is used in a salary equity study, the institutional researcher will: (a) obtain a value that measures the difference between the salaries of the female and male faculty for each year of a multi-year span of data and (b) estimate and incorporate into the evaluation technique the year-to-year variability in those values.

Implementation

Setting the process aim technique, when applied to a salary equity study, will allow a researcher to determine if the salary system has generated salary data that indicate that the system is discriminatory. An institutional researcher would follow nine steps when implementing the process aim setting technique in a salary equity study.

Step 1. The institutional researcher would generate an average residual value for the female faculty members for each year of a multi-year set of salary data, when the male-model approach was used. If the one-model approach was used, the percentage difference between male and female salaries, which is referred to as the percent-difference value, would be calculated from the gender variable coefficient for each year of a multi-year set of data.

Step 2. The institutional researcher would calculate the moving range values (mR) for the average residual values or the percent-difference values, depending on which regression procedure was used. Each moving range value would be calculated for consecutive years by subtracting the smaller value from the larger value. Thus, if each of five years of salary data were analyzed, four moving range values would be recorded.

Step 3. The institutional researcher would calculate the average moving range value ($\overline{mR}$) as follows:

$$\bar{mR} = \frac{\text{Sum of the moving range values}}{\text{Number of the moving range values}} \qquad \text{[Equation 2]}$$

This average moving range value will be used in Step 4 to calculate an estimate of the standard deviation (SigmaX) of the values generated from the regression analyses. This estimate of the standard deviation will, in turn, be used in Steps 5 and 6 to calculate the control limits for the individual values chart and the moving range chart, which are the two charts used in the process aim setting technique. In addition, this average moving range value serves as the center line on the moving range chart.

Step 4. The standard deviation estimate of the values generated from the regression analyses would be calculated as follows:

$$\text{SigmaX} = \frac{\bar{mR}}{1.128} \qquad \text{[Equation 3]}$$

As previously mentioned, this estimate of the standard deviation of the values generated by the regression analyses will be used to calculate the control limits for the individual values and moving range charts.

Step 5. The institutional researcher would construct the individual values chart by, first, setting a target value for the values generated by the regression analyses. Since the average residual values or the percent-difference values will vary around zero in a nondiscriminatory salary system, the center line for the individual values chart would be set at zero.

Next, the institutional researcher must calculate the chart's one-, two-, and three-sigma control limits. These control limits would be calculated as follows:

one-sigma limits = target value $\pm$ 1(SigmaX) [Equation 4]

two-sigma limits = target value $\pm$ 2(SigmaX) [Equation 5]

three-sigma limits = target value $\pm$ 3(SigmaX) [Equation 6]

Finally, the institutional researcher would construct the individual values chart by drawing a solid line on a graph at the level of the target value and dashed lines at the levels of the six control limit values. The average residual values or the percent-difference values, depending on which regression approach was used, would be plotted on the individual values chart.

Step 6. The institutional researcher would construct a moving range chart, by, first, setting the chart's center line equal to the average moving range value. Next, the upper control limit for the chart (UCL_{mR}) would be calculated as follows:

$$UCL_{mR} = 3.686(SigmaX) \qquad \text{[Equation 7]}$$

Finally, the institutional researcher would draw a solid line and dashed line on the chart at the level of the average moving range value and the level of the upper control limit value, respectively. In addition, the moving range values would be plotted on the chart.

Step 7. The Western Electric Zone Rules, which are used to detect a gender salary discrimination signal, would be applied to the values plotted on the individual values chart. A gender discrimination signal would be detected whenever:

Rule I: One value is located outside the three-sigma limits.

Rule II: At least two out of three successive values are located beyond one of

the two-sigma lines and they are located on the same side of the center line.

Rule III: At least four out of five successive values are located beyond one of the one-sigma lines and they are located on the same side of the center line.

Rule IV: Eight successive values are located on the same side of the center line.

If a gender discrimination signal is not detected, the researcher would skip to Step 9.

Only Rule I would be applied to the moving range chart. As noted by Wheeler (1994), "because of the artificial autocorrelation which occurs with all moving statistics, one should not attempt to use run tests [Rules II through IV] with the Moving Ranges" (p. 85). Although, the moving range chart is only of secondary interest in the process aim setting technique, it can, however, be used by the institutional researcher to detect a change in the dispersion of the values generated by the regression analyses. Such a change would merit a review of salary system to determine why the variation in the values generated by the regression analyses, which attempt to measure the difference between the female and male faculty salaries, has become larger.

Step 8. When a gender discrimination signal is detected in the individual values chart by any of the four Western Electric Zones Rules, the researcher would estimate the total amount of money required to address the gender-discrimination problem. If the male-model approach was used, the amount of money required to adjust the salary system would be determined by, first, calculating the absolute value

of the average of the values plotted on the individual values chart since the last salary adjustment for gender discrimination. This average value would give the institutional researcher an estimate of the value around which the average residual values that were generated by the discriminatory salary system center. Multiplying this average residual value by the number of faculty members in the group that was discriminated against would provide an estimate of the amount of money required to adjust the salary system.

When the male-model approach was used, the institutional researcher would, first, divide by 100 the absolute value of the average of the percent-difference values recorded since the last salary adjustment for discrimination. This quotient would be multiplied by the total salary figure for the group requiring salary adjustments to obtain an estimate of the total amount of money needed to adjust the salary system.

Step 9. The institutional researcher would continue to monitor the salary system by plotting the average residual value or the percent-difference value for following year's salary data on the individual values chart. In addition, the researcher would calculate the moving range value for the new year and plot it on the moving range chart. After plotting these values, the institutional researcher would return to Step 7 and continue the process aim setting technique. Continuing to use the process aim setting technique would serve two purposes. First, the institutional researcher could evaluate the impact of the adjustments made in faculty salaries that were made

in response to a gender-discrimination signal. Second, the institutional researcher could monitor the salary system for future gender salary discrimination signals. The investigation of gender-salary discrimination should not be a one-shot project.

Application to Hypothetical Data

The use of the aim setting technique to detect a gender-salary discrimination signal among salary data, as well as its use to estimate the amount of money needed to adjust the salaries of the underpaid group, may best be understood through its application to two hypothetical examples. The first example illustrates how the process aim setting technique would be used to evaluate five average residual values, which were generated, hypothetically, by the male-model method. The second example demonstrates how this technique would be used to analyze the percent-difference values, which were generated, again hypothetically, by the one-model approach.

Application to Average Residual Values

In this first example, it is assumed that the institutional researcher used the male-model approach to determine if gender-salary discrimination existed in the salary system. It is also assumed that the institutional researcher collected five years of salary figures and data for the predictor variables. As previously discussed, the institutional researcher would apply the process aim setting technique by following nine steps.

Step 1. The institutional researcher generated an average residual value for the female faculty members for each year's data by using the male-model approach. The hypothetical residual values for the female faculty members are listed in Table 1. To understand the interpretation of these values, consider the average residual value of -$480, which was recorded for Year 1. This value indicates that the actual salaries of the female faculty members were, on the average, $480 less than their predicted salaries.

Insert Table 1 about here

Step 2. The four moving range values, which were calculated from the five average residual values, are listed in Table 1. Each moving range value was calculated by subtracting the smaller average residual value from the larger average residual value recorded for two consecutive years. For example, the moving range value of $586 for Year 2 was calculated by subtracting -$1066 from -$480.

Step 3. The average moving range value ($\overline{mR}$) was calculated using Equation 2 as follows:

$$\overline{mR} = \$2020/4 = \$505$$

Step 4. Equation 3 was used to calculate the standard deviation for the average residual values as follows:

$$\text{SigmaX} = (\$505)/(1.128) = \$448.$$

Step 5. Equations 4, 5, and 6 were used to calculate the one-, two-, and three-sigma control limits, respectively, for the individual values chart as follows:

$$\text{One-Sigma Limit} = \$0 \pm 1(\$448) = -\$448 \text{ and } +\$448$$

$$\text{Two-Sigma Limit} = \$0 \pm 2(\$448) = -\$896 \text{ and } +\$896$$

$$\text{Three-Sigma Limit} = \$0 \pm 3(\$448) = -\$1344 \text{ and } +\$1344.$$

These one-, two-, and three-sigma limit values, along with the target value of zero, which serves as the center line, were used to construct the individual values chart contained in Figure 1. The average residual value for each year is plotted on this individual values chart.

Insert Figure 1 about here

Step 6. The upper control limit for the range chart was calculated using Equation 7 as follows:

$$UCL_{mR} = 3.686(\$448) = \$1651$$

This upper control limit value of $1651 and the average moving range value of $505, which serves as the center line, were used to construct the moving range chart contained in Figure 1. The four moving range values were plotted on this chart.

Step 7. The four Western Electric Zone Rules were applied to the individual values chart and Rule I was applied to the moving range chart. A signal that would

indicate a change in the dispersion of the average residual values was not detected in the moving range chart. An examination of the values in the individual values chart, however, revealed that four of the five values were located more than one standard deviation value below the target value of zero. Thus, Rule III detected a gender salary discrimination signal.

Step 8. Since a gender salary discrimination signal was detected in the individual values chart, the amount of money required to adjust the process aim was estimated. To estimate the total dollar figure required to adjust the process aim, the institutional researcher, first, calculated the absolute value of the average of the average residual values recorded since the last salary adjustment for discrimination. Since this salary system has not been adjusted for the past five years, all five of the average residual values were included in this calculation. The absolute value of the average of the five average residual values was $694.40.

This absolute value of the average of the average residual values was multiplied by the number of female faculty members to obtain an estimate of the total dollar amount needed to adjust the process aim. If this hypothetical university had 110 female faculty members who were included in the salary data for the current year, the estimate of the total amount of money needed to adjust the process aim would be equal to $76,384, which was calculated by multiplying $694.40 per faculty member by 110 faculty members.

Step 9. After adjusting the salaries of the female faculty members, the institutional researcher should continue to monitor the salary system by obtaining an average residual value from the next year's salary figures by using the male-model approach. Once the average residual value was calculated along with the corresponding moving range value, the researcher would plot those values on the appropriate charts. The institutional researcher would continue using the process aim setting technique, starting with Step 7.

Application to Percent-Difference Values

For the second hypothetical example, it is assumed that the salary data were analyzed by the one-model approach. Five years of data were used in the initial study, and a sixth year's data were analyzed to monitor the salary system.

Step 1. The institutional researcher analyzed each year's data by utilizing the male-model method. A hypothetical regression coefficient for the gender variable was listed in Table 2 for each of the initial five years of salary data. It should be noted that for this hypothetical example it was assumed that the regression coefficient values for the gender variable were generated by regression models in which the natural logarithmic values of the salary figures were used.

Insert Table 2 about here

The percentage difference between the salaries of the male and female faculty members for each year was calculated from the gender coefficient by using Equation 1. The five percent-difference values are listed in Table 2. To illustrate the interpretation of these values, which were analyzed by the process aim setting technique, consider the value of .9% for Year 1. This value indicates that the average male salary was .9% higher than the average female salary, adjusting for the other predictor variables included in the regression analysis.

Step 2. The four moving range values that were calculated from the five percent-difference values are also listed in Table 2.

Step 3. The average moving range value ($\overline{mR}$) was calculated using Equation 2 as follows:

$$\overline{mR} = (6.2\%)/4 = 1.55\%.$$

Step 4. Using Equation 3, the average moving range value of 1.55% was divided by 1.128 to obtain 1.4%, which was the estimate of the standard deviation of the percent-difference values.

Step 5. Equations 4, 5, and 6 were used along with the target value of zero for the percent-difference values to calculate the one-, two-, and three-sigma limits as follows:

$$\text{One-Sigma Limit} = \$0 \pm 1(1.4\%) = -1.4\% \text{ and } +1.4\%$$

$$\text{Two-Sigma Limit} = \$0 \pm 2(1.4\%) = -2.8\% \text{ and } +2.8\%$$

$$\text{Three-Sigma Limit} = \$0 \pm 3(1.4\%) = -4.2\% \text{ and } +4.2\%.$$

These limits, along with the five percent-difference values calculated for Years 1 through 5, were plotted on the individual values chart contained in Figure 2.

Insert Figure 2 about here

Step 6. Equation 7 was used to calculate the upper control limit for the moving range chart as follows:

$$UCL_{mR} = 3.686(1.4\%) = 5.2\%.$$

The upper control limit value of 5.2% and the average moving range value of 1.55% were used to construct the moving range chart contained in Figure 2. The four moving range values listed in Table 2 were plotted on this moving range chart.

Step 7. The four Western Electric Zone Rules were applied to the individual values chart and Rule I was applied to the moving range chart. Since a signal was not detected in the moving range chart, the institutional researcher concluded that the dispersion of percent-difference values had not changed. More importantly, a gender salary discrimination signal was not detected in the individual values chart. Thus, the individual values chart did not provide sufficient evidence for the institutional researcher to conclude that gender-salary discrimination exists, and therefore, faculty salaries should not be adjusted. The institutional researcher continued to monitor the salary system by skipping to Step 9.

Step 9. The institutional researcher collected and analyzed the following year's salary data. Table 2 and Figure 2 contain the percent-difference value generated by the regression analysis of the salary data recorded for the year following the initial discrimination assessment. Once this value was calculated along with the corresponding moving range value, the institutional researcher returned to Step 7.

Step 7. The application of the Western Electric Zone Rules to the individual values chart, which contains the percent-difference value for the sixth year, indicated the presence of a gender salary discrimination signal. That is, two out of three successive values, which are the values for the fifth and sixth year, were located outside of the same two-sigma limit. Thus, evidence exists that the salary system is discriminatory. It should be noted that the Western Electric Zone Rules were also applied to the moving range chart, and again, a signal was not detected.

Step 8. Since a gender salary discrimination signal was detected in the individual values chart, the institutional researcher addressed the need to adjust the salary levels of the female faculty members. The amount of money needed to adjust the salary system was estimated by, first, calculating the absolute value of the average of the percent-difference values that were recorded since the last salary adjustment for gender discrimination. Assuming that the salary system, which generated the values listed in Table 2, had not been adjusted for gender discrimination prior to the initiation of this salary equity study, all six percentage difference values were used to calculate the average percent-difference value of 1.7%. This figure of 1.7% was

divided by 100 and multiplied by the total salary figure for the female faculty members. Assuming that the total salary figure for the female faculty members included in this hypothetical example was $3,850,000, the estimate of the amount of money required to adjust the salary system would be $65,450, which was obtained by multiplying .017 by $3,850,000.

After the female salaries are adjusted, the institutional researcher would continue on to Step 9. Completing Step 9 would allow the institutional researcher to continually monitor the salary system, as well as evaluate the impact of the salary adjustments.

Important Issues

Three issues related to the use of the process aim setting technique in a salary equity study are important to discuss. These issues are: (a) the number of years of data that should be analyzed, (b) the use of longitudinal salary data, and (c) the need to study and change the salary system when a gender salary discrimination signal is detected.

Number of Years

One of the most important issues that the institutional researcher must resolve before the process aim setting technique can be used to separate a gender discrimination signal from the noise of the salary system is the number of years of salary data that should be used to estimate the standard deviation of the values and construct the charts. Wheeler (1991) recommends that between 5 and 10 values be

used to estimate the standard deviation of the values that will be monitored by the process aim setting technique. Obviously, the greater the number of values used to generate the standard deviation value, the more accurate will be the estimate.

In spite of the fact that an institutional researcher's efforts may be constrained by the limited financial resources and time allotted to a salary study, I recommend that a strong attempt be made to use at least five years of salary data. An institutional researcher may balk at the need to collect five years of salary data, but once the chart has been constructed with these values, it will serve as a basis by which the salary system can be monitored in the future. If it is not possible to use five years of salary data, I believe that it is better to use the process aim setting technique with fewer than five years of data than not to use the technique to determine if a gender salary discrimination signal exists.

Longitudinal Salary Data

The fact that numerous years of salary data are analyzed is an essential element in the philosophical underpinnings of the process aim setting technique. An institutional researcher should be aware of a potential problem with the use of multi-year data that may cause a gender salary discrimination signal not to be detected. Gray and Scott (1980) noted: "It is clear ... [that] excluding those [female] faculty members who left the institution during the period under study could well introduce bias, in particular if they left because their prospects for promotion or salary increments were poor" (p. 176).

If a greater proportion of female than male faculty members leave the institution because they view their prospects for promotion and appropriate salaries more negatively, the regression estimates produced by the male-model approach and the one-model approach may underestimate the difference between the salaries of the female and male faculty produced by the salary system. The application of the process aim setting technique to such estimates may cause the researcher to miss a gender-salary discrimination signal that would have been detected if those female faculty members had not left the institution.

Thus, when the process aim setting technique is used to detect gender-salary discrimination, the institutional researcher should review the salary data of those faculty who have left the institution. This review may include the person's actual salaries, predicted salaries for the years prior to the person's departure, and other qualitative information, such as the stated reason for leaving the institution. This review of salary data for the faculty who have left the institution may reveal a gender discrimination problem not detected by the process aim setting technique. Although not the focus of this paper, it is important that various methods of evaluating the data of the faculty who leave the institution be developed and discussed.

Reacting to a Signal

If the process aim setting technique identified a gender salary discrimination signal and the salaries of the discriminated group are adjusted, the university administration must realize what has and has not been accomplished. What has been

accomplished is the adjustment of salaries in what is believed to be a discriminatory salary system. Those salary adjustments do not, however, attack the underlying causes of the discrimination.

If these underlying causes are not identified and dealt with, over a period of time, the salaries of the group who received salary adjustments will, in all likelihood, again lag behind the salaries of their colleagues. The methods used to identify and handle these underlying causes, while not the focus of this paper, are very important for an institution's administration and faculty to develop and discuss. The point is, identification of a gender salary discrimination signal and appropriate changes in salary levels are not the only tasks facing university administrators and faculty who deal with salary inequities. The discriminatory salary system that generated those salaries must be studied and changed.

Summary

Two basic multiple regression methodological approaches are used in salary equity studies: (a) the male-model approach and (b) the one-model approach. Regardless of which regression method is used in a salary equity study, the researcher must determine whether the gender salary differences do, in fact, signal that gender discrimination exists or whether it simply reflects the variation in the estimates of the differences between male and female faculty salaries that can exist from time to time in a nondiscriminatory salary system.

The institutional researchers who utilize the male-model approach have not attempted to separate a gender salary discrimination signal from the normal variation in the gender salary difference estimates. The institutional researchers who employ the one-model technique typically use a *t* test of the regression coefficient generated for the gender variable to determine if the estimate represents a gender salary discrimination signal. This test, however, does not measure the variation in this coefficient value from one year to the next. Thus, the *t* test of the coefficient for the gender variable does not evaluate the appropriate unit of analysis if one wants to identify a gender-salary discrimination signal.

The statistical process control technique known as setting the process aim, when used in a salary equity study, is an appropriate technique for evaluating the estimates of gender-salary differences. Using this technique, an institutional researcher can determine whether these estimates, which are generated by either the male-model approach or the one-model approach, indicate that the salary system is discriminatory or whether the values are simply the product of a nondiscriminatory salary system. When a salary discrimination signal is detected, the process aim setting technique can also be used to estimate the amount of money required to adjust the faculty salaries.

It is important that an institution of higher education react to the presence of gender salary discrimination signal and adjust faculty salaries accordingly. An institution should not, however, attempt to adjust a salary system in the absence of

such a signal. Using the process aim setting technique in a salary equity study will enable an institutional researcher to judge which action is appropriate.

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Table 1

Hypothetical Average Residual Values for Example 1

Year	Average Residual Value	Moving Range Value
1	-$ 480	---
2	-$1066	$586
3	-$ 754	$312
4	-$ 268	$486
5	-$ 904	$636

Table 2

Hypothetical regression coefficients for the gender variable and the percent-difference values for example 2

Years[a]	Regression Coefficient	Percent-Difference Values[b]	Moving Range Values
1	.00896	.9	---
2	-.01005	-1.0	1.9
3	.01292	1.3	2.3
4	.02176	2.2	.9
5	.03247	3.3	1.1
6	.03440	3.5	.2

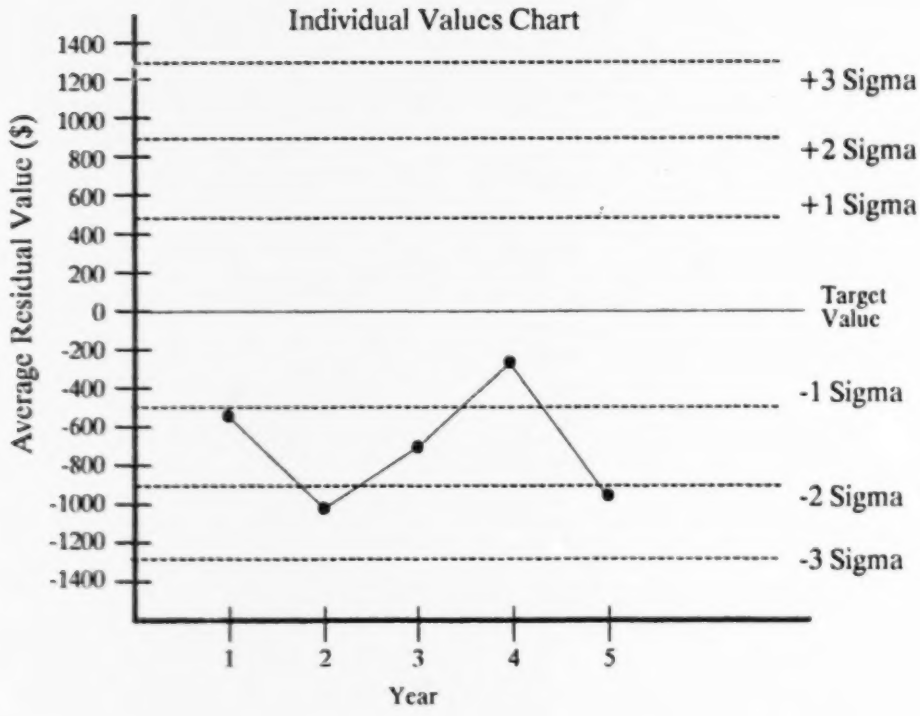
[a]Years 1 through 5 were used to construct the control limits.

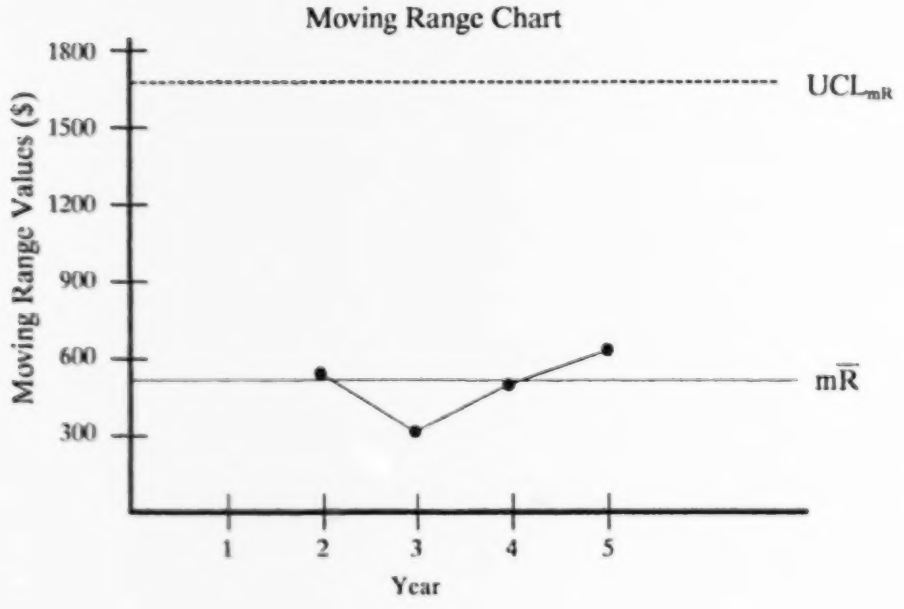
[b]The percent-difference values were calculated from the hypothetical gender coefficient values as follows: % Difference = $100(e^{b}-1)$ where e is equal to 2.7183 and b is the regression coefficient value.

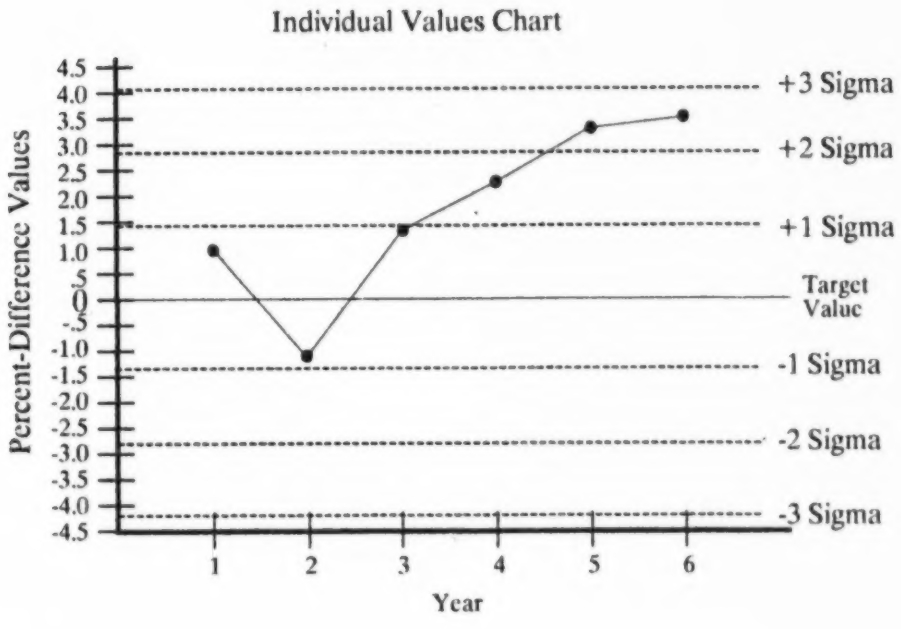
Figure Captions

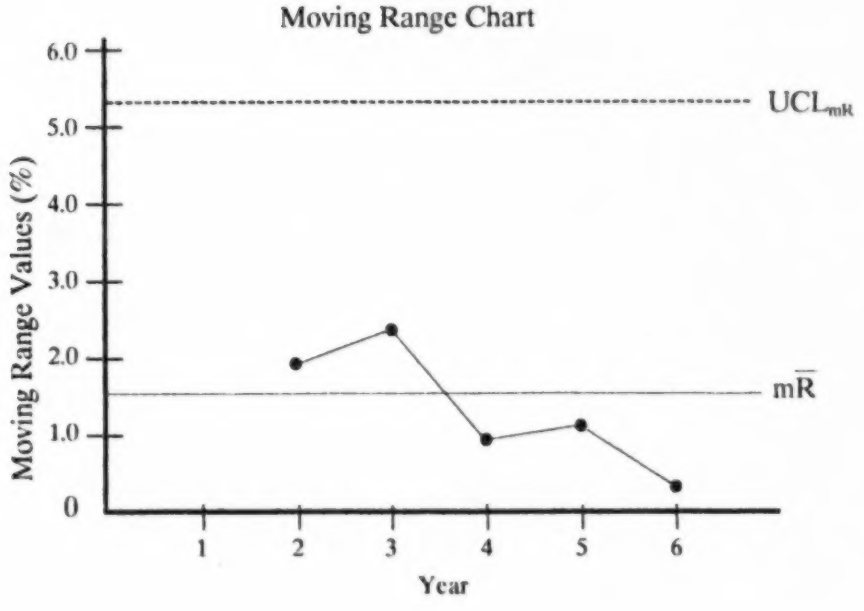
Figure 1. Individual values chart and moving range chart for example 1.

Figure 2. Individual values chart and moving range chart for example 2.


Individual Values Chart
Average Residual Value ($)
1400
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
+3 Sigma
+2 Sigma
+1 Sigma
Target Value
-1 Sigma
-2 Sigma
-3 Sigma
1
2
3
4
5
Year


Moving Range Chart
Moving Range Values ($)
1800
1500
1200
900
600
300
UCL_{mR}
$\overline{mR}$
1
2
3
4
5
Year


Individual Values Chart
Percent-Difference Values
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
-.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
+3 Sigma
+2 Sigma
+1 Sigma
Target Value
-1 Sigma
-2 Sigma
-3 Sigma
1
2
3
4
5
6
Year


Moving Range Chart
Moving Range Values (%)
6.0
5.0
4.0
3.0
2.0
1.0
0
UCL$_{mR}$
$\overline{mR}$
1
2
3
4
5
6
Year